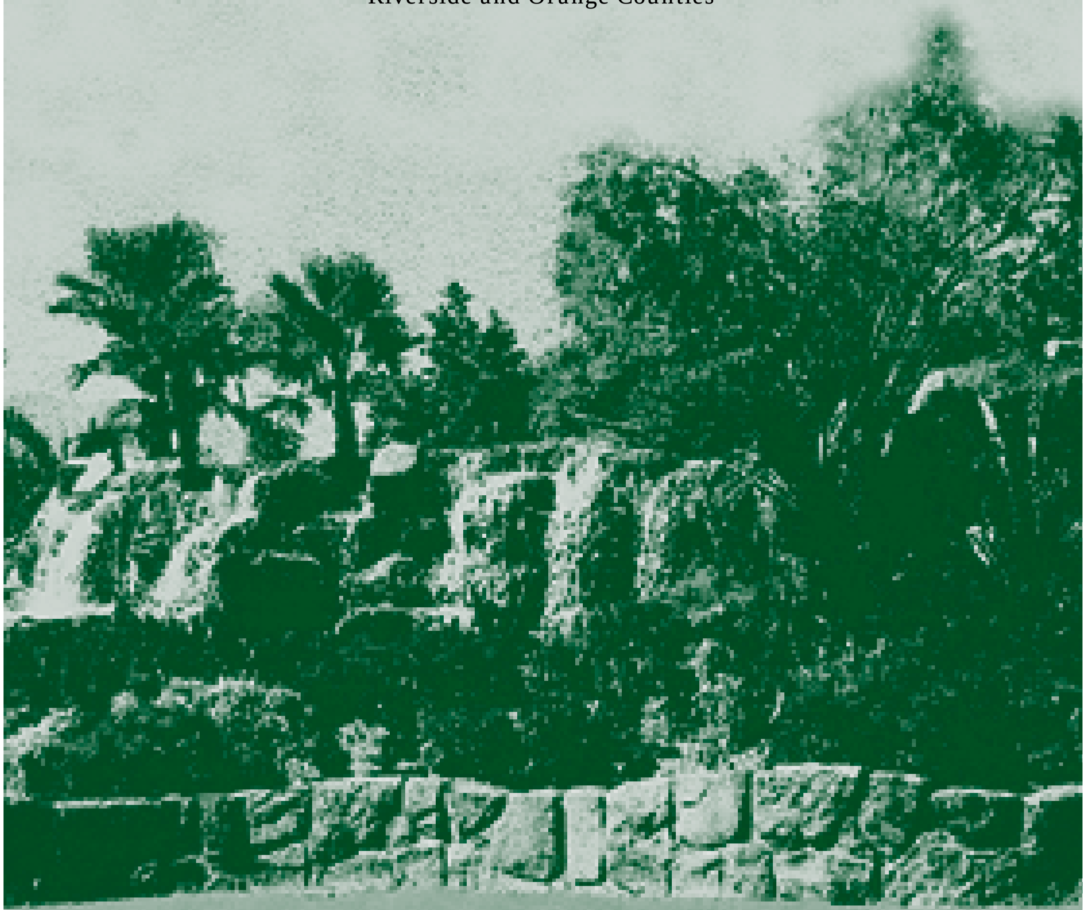
Best Management Practices to Reduce Production of Organic Materials in Landscape Plantings

Janet Hartin
Environmental Horticulture Advisor
University of California Cooperative Extension
San Bernardino and Los Angeles Counties

Dennis Pittenger
Environmental Horticulture Advisor
University of California Cooperative Extension
Southern Region and Los Angeles County

J. Michael Henry
Environmental Horticulture Advisor
University of California Cooperative Extension
Riverside and Orange Counties



This publication is one of a series developed by the California Integrated Waste Management Board (CIWMB) under an interagency agreement with the Regents of the University of California/Department of Agricultural and Natural Resources. Prepared under contract number IWM-C8085 ($20,000).

Integrated Waste Management Board

BEST MANAGEMENT PRACTICES TO REDUCE PRODUCTION OF ORGANIC MATERIALS IN LANDSCAPE PLANTINGS

Introduction

Following proper horticultural practices can significantly reduce the production of organic materials in landscape plantings. Implementing recommended irrigation, fertilization, and other cultural practices can reduce the vegetative growth of turfgrass and woody plants without sacrificing aesthetic appeal or performance. Employing the techniques described in this publication will enable landscape managers to achieve both of these goals.

Turfgrass Irrigation Management

Proper turfgrass irrigation management is important to optimize plant health and to reduce unnecessary production of organic matter. Scheduling irrigations based on water requirements of the turfgrass is one of the most important management practices available to promote healthy and attractive turfgrass plantings able to withstand traffic and other stresses. Irrigation scheduling involves applying the right amount of water over the correct amount of time, based on the evapotranspiration (ET) rate of the plant. (Evapotranspiration is the combined water loss from the soil surface and through the plant; reference evapotranspiration, or ETo, is an estimate of the amount of water used by healthy 4- to 6-inch-tall cool-season turfgrass.) Too much water can result in diseased turfgrass and unsafe, flooded parks and playing fields, while too little water can lead to a thin stand of poorly growing turfgrass with low vigor, poor recuperative ability and appearance, and unsafe playing conditions for sports such as soccer and football.

There are two effective methods for scheduling turfgrass irrigation. While both methods result in optimal irrigation and minimal water waste, **Method 1** is especially targeted to management personnel with limited time and resources who are interested in increasing turfgrass quality while decreasing an overabundance of clippings that makes grasscycling difficult. **Method 2** is targeted toward personnel with greater time and resources who are interested in fine-tuning their irrigation scheduling practices to an even greater extent and is based on results of a more precise "can test" than **Method 1**. It offers the option of using real-time ETo information available through the California Irrigation Management Information System (CIMIS), discusses the use of tensiometers, and describes how to mathematically determine the distribution uniformity (DU), application rate, net amount of water to apply, and sprinkler run times. **Method 1** will provide a close approximation of irrigation requirements when climactic conditions are near average. During an unusual weather pattern that persists for an extended period, **Method 1** may not accurately predict ET, and the turfgrass should be monitored closely for signs of too much or too little water, with necessary corrections made.

Wound dressings–Wound dressings were once thought to accelerate wound closure, protect against insects and diseases, and reduce decay. However, research disputes these benefits and experts recommend that wound dressing not be used.

Pruning Mature Landscape Trees

Pruning mature trees is important for functional and aesthetic reasons. Proper pruning, based on principles of tree biology, can maintain good tree health and structure while enhancing the aesthetic and economic values of urban landscapes.

Reasons for Pruning–In most cases, mature trees are pruned for corrective or preventative measures. Common reasons for pruning are to remove dead, crowded, or poorly-angled limbs; reduce potential hazards; and to increase light and air penetration.

Routine thinning does not always improve the health of a tree. Trees produce a dense crown of leaves to produce compounds necessary for growth and development. Removing large amounts of foliage can reduce growth and stored energy reserves, resulting in stressed trees.

When to Prune–In most cases, routine pruning to remove weak, diseased, or dead limbs can be accomplished at any time of year with little effect on the tree. In general, tree growth is maximized and wound closure occurs most readily if pruning takes place before the spring growth flush. Heavy pruning just after this growth flush should be avoided, to conserve energy and reduce stress. In some cases, opportunities for disease spread occur in some species during certain times of the year, which obviously need to be avoided.

Making Proper Pruning Cuts–Pruning cuts for mature trees should be made just outside the branch collar, as is the case with immature trees. The branch collar contains trunk tissue that needs to be preserved.

The weight of large limbs that require removal should be reduced before they are removed to minimize the risk of tear and damage. An undercut 12-18 inches from the point of attachment should be made, followed by a second cut from the top directly above or a few inches further out on the limb. The remaining stub should be removed by cutting back to the branch collar.

Pruning Techniques–Specific types of pruning may be necessary to maintain a mature tree in a healthy, safe, and attractive condition. Trees should not be topped! Instead, use the following techniques to insure safety and preserve the structural integrity of the tree. Crown cleaning is the removal of dead, dying, diseased, crowded, weakly attached, and low-vigor branches from the crown of a tree. Crown thinning is the selective removal of branches to increase light penetration and air movement through the crown. Thinning opens the foliage of a tree, reduces weight on heavy limbs, and helps retain the natural shape of a tree. Crown raising removes the lower branches to provide clearance for buildings, vehicles, pedestrians, and vistas. Crown reduction reduces the overall tree size, often for clearance for utility lines. Reducing the height or spread of a tree is best accomplished by pruning back the leaders and branch terminals to lateral branches that are large enough to assume the terminal roles (at least one-third the diameter of the cut branch).

The amount of live tissue that should be removed depends on the tree size, species, age, and pruning objectives. An important principle is that a tree can recover from several small pruning wounds faster than from one large wound.

It is important to avoid removing too much inner foliage and small branches. An even distribution of foliage should be maintained along large limbs and in the lower portion of the crown. Over-thinning reduces photosynthate production and can lead to limb failure.

Mature trees do not ordinarily require major routine pruning. In general, less than one-fourth of the leaf-bearing crown should be removed during any given pruning. In older, more mature trees, removing a single, large-diameter limb can result in a wound that is difficult to close. As a tree ages, it has a reduced ability to close wounds and defend against decay and insect attack. Therefore, the pruning of large, mature trees is usually limited to the removal of dead or potentially hazardous limbs. Wound dressings do not accelerate wound closure, protect against insects and diseases, or reduce decay, and, therefore, should not be used.

Fertilizing Landscape Trees

Controversy has always surrounded the issue regarding routine fertilization of landscape trees. Some studies indicate no increases in growth when fertilizers are added, while many professionals recommend fertilizing landscape trees as soon as they are planted. It is important to remember that landscape trees are not a crop plant that require certain nutrients at certain developmental cycles for optimum production. In general, most healthy, mature, well-established trees require little fertilizer. However, fertilizer is often beneficial to promote more rapid growth and faster establishment in newly planted trees or in older trees exhibiting a nutrient deficiency, such as nitrogen. It may be useful to evenly broadcast a complete fertilizer (e.g., 15-15-15, 11-4-8) at the recommended label rate (usually 1/3 to 1/2 pound of actual nitrogen per inch trunk diameter) over the soil surface to the drip line of the tree or slightly beyond to optimize growth of young, maturing trees. Older trees may benefit from applications at half rates applied in spring prior to rapid growth and again in mid-summer. Fertilizers should be irrigated in thoroughly to move nutrients vertically into the root zone.

How a pruning cut is made is critical to the growth response and wound closure of the tree. Pruning cuts should be made just outside the branch collar. The collar itself contains trunk or parent branch tissues leading to damage when cut. A permanent branch may be shortened by pruning it back to a lateral branch or bud. Internodal cuts, or cuts made between buds or branches, may lead to stem decay, sprout production, and misdirected growth.

PRUNING TOOLS–Proper tree pruning requires using the correct tool for required procedures. Selected tools should be routinely cleaned and sharpened for optimum performance, as well. For small trees, most of the cuts can be made with hand pruning shears (secateurs). The scissor type or bypass blade hand pruners are preferred over the anvil shears because they make cleaner, more targeted cuts. However, pruning cuts larger than 1/2 inch in diameter should be made with lopping shears or a pruning saw. Never use hedge shears to prune a tree.

Establishing a strong scaffold structure is necessary while the tree is young because scaffold branches provide the framework for the mature tree. Properly trained young trees will develop a strong structure that will require less corrective pruning during maturation.

Good pruning techniques remove structurally weak branches while maintaining the natural form of the tree. In fact, it is often difficult to visually determine whether a landscape tree has been pruned following a high quality pruning. A major goal when training young trees is to establish a strong trunk with sturdy, properly spaced branches. The strength of the branch structure depends on the relative sizes of the branches, the branch angles, and the spacing of the limbs. These factors vary among species due to individual growth patterns. Some trees, such as pin oaks and liquidambars, have conical, upright shapes with a strong central leader. Conversely, elms and live oaks are usually wide-spreading without a dominant central leader. Some trees, like *Ficus nitida* and Bradford pears, are densely branched.

LEADER DEVELOPMENT–In most cases, a single, dominant leader should be allowed to develop in a young tree. The tip should not be pruned back and competing branches should not be allowed to outgrow the leader. A tree with a double leader is prone to structural weaknesses; the strongest, most upright leader should be selected and the second one removed while the tree is young.

Lateral branches (known as temporary branches) often contribute to the development of a sturdy, well-tapered trunk. It is important to leave some in place, although they may need to be removed later. Temporary branches may also help protect the trunk from sun and mechanical injury. They should be kept short enough to avoid creating obstructions or competition with permanent branches.

SELECTING PERMANENT BRANCHES–Nursery trees often have low branches that appear well placed on a young tree, but are inappropriate for large growing trees in an urban environment. The primary function the tree will serve at maturity should determine how a young tree is trained. For example, street trees should be pruned so that they allow at least 16 feet of clearance for traffic, while many landscape trees require only about eight feet of clearance.

The height of the lowest permanent branch is also determined by the intended function of the tree and its function in the landscape. Trees that are used to screen an unsightly view or provide a wind break may be allowed to branch low to the ground. Most large growing trees in the landscape should eventually be pruned to allow head clearance.

Vertical and radial branch spacing is critical to future development and structural strength of the tree. Branches selected as permanent, scaffold branches should be properly spaced along the trunk. In general, permanent branches that are vertically spaced at distances equal to about three percent of the ultimate height of the tree are preferred. Therefore, a tree expected to grow 50 feet tall should have permanent scaffold branches spaced about 18 inches apart along the trunk, while scaffold branches should be spaced approximately seven inches apart for species growing an average of 20 feet tall.

Scaffold branches should be spaced radially to avoid two growing next to each other on the same side of the tree. Some trees have a tendency to develop branches with narrow angles of attachment and tight crotches. As these trees develop, bark may become enclosed deep within the crotch between the branch and the trunk, which weakens the attachment of the branch to the trunk and can lead to branch failure when the tree matures. Branches with these types of weak attachments should be pruned while they are young.

Research indicates that the structural integrity of a tree can best be maintained by promoting the development of half of the branches in the lower 2/3 of the tree. Also, it is important to avoid over-thinning the interior of the tree. Removing too many leaves can reduce the photosynthetic production of the tree, leading to poor growth and development and stress.

RECENTLY PLANTED TREES–Recently planted trees should not be heavily pruned, but may require minor corrective pruning. Broken and damaged branches should be removed, but more comprehensive pruning and training should occur over the next few years.

The belief that trees should be pruned when planted to compensate for root loss is misguided. Instead, trees should be allowed to retain as much foliage as possible to provide necessary photosynthetic material for optimum shoot and root growth. Unpruned trees establish faster, and develop a stronger root system than trees pruned at the time of planting.

METHOD 1

This method of irrigation scheduling uses average (historical) ETo recorded over several years to estimate ET of warm- and cool-season turfgrasses on a weekly basis. Table 1 (Minutes to Irrigate Warm- and Cool-Season Turfgrasses per Week in California) was computed from these data. ETo is an estimate of the amount of water used by healthy 4-6 inch cool-season turfgrass. **Table 1** reflects the fact that research indicates that warm-season turfgrass require about 20 percent less water than cool-season turfgrass.

1 Determine the sprinkler system precipitation rate (output)

Set a minimum of six, straight-sided cans of the same type (any straight-sided cans may be used, or they can be purchased from a variety of grocery store suppliers) between sprinkler heads receiving water from the same valve. If possible, space cans on 10- or 15-foot centers for more accurate results. Run the sprinklers for 15 minutes and measure the depth of water in each can with a ruler; record each depth on a

Table 1. Minutes to Irrigate Warm- and Cool-Season Turfgrass per Week in California

SOUTHERN CALIFORNIA COAST

	Warm-Season Turfgrasses: Minutes to irrigate/week if hourly sprinkler output is:					Cool-Season Turfgrasses: Minutes to irrigate/week if hourly sprinkler output is:			
	0.5 in	1.0 in	1.5 in	2.0 in		0.5 in	1.0 in	1.5 in	2.0 in
JAN	44	22	15	11	JAN	59	29	20	15
FEB	57	28	19	14	FEB	76	38	25	19
MAR	63	32	21	16	MAR	84	42	28	21
APR	76	38	25	19	APR	101	50	34	25
MAY	88	44	29	22	MAY	118	59	39	29
JUN	95	47	32	24	JUN	126	63	42	32
JUL	107	54	36	27	JUL	143	71	48	36
AUG	95	47	33	24	AUG	126	63	42	32
SEP	82	41	27	20	SEP	109	55	36	27
OCT	69	35	23	17	OCT	92	46	31	23
NOV	50	25	17	13	NOV	67	34	22	17
DEC	38	19	13	9	DEC	50	25	17	13

SOUTHERN CALIFORNIA INLAND VALLEYS

	Warm-Season Turfgrasses: Minutes to irrigate/week if hourly sprinkler output is:					Cool-Season Turfgrasses: Minutes to irrigate/week if hourly sprinkler output is:			
	0.5 in	1.0 in	1.5 in	2.0 in		0.5 in	1.0 in	1.5 in	2.0 in
JAN	42	21	14	10	JAN	56	28	19	14
FEB	57	28	19	14	FEB	75	38	25	19
MAR	80	40	27	20	MAR	106	53	35	27
APR	96	48	32	24	APR	128	64	43	32
MAY	119	60	40	29	MAY	159	80	53	40
JUN	144	72	48	36	JUN	193	96	64	48
JUL	165	83	55	41	JUL	221	110	74	55
AUG	155	77	52	39	AUG	207	103	69	52
SEP	124	62	41	31	SEP	165	82	55	41
OCT	88	44	29	22	OCT	117	59	39	29
NOV	54	27	18	14	NOV	73	36	24	18
DEC	42	21	14	10	DEC	55	28	19	14

SOUTHERN CALIFORNIA DESERTS

	Warm-Season Turfgrasses: Minutes to irrigate/week if hourly sprinkler output is:					Cool-Season Turfgrasses: Minutes to irrigate/week if hourly sprinkler output is:			
	0.5 in	1.0 in	1.5 in	2.0 in		0.5 in	1.0 in	1.5 in	2.0 in
JAN	54	27	18	14	JAN	65	32	22	17
FEB	75	38	25	19	FEB	90	46	30	23
MAR	121	61	40	30	MAR	145	73	48	36
APR	165	83	55	41	APR	198	100	66	49
MAY	211	106	70	53	MAY	253	127	84	64
JUN	243	121	81	61	JUN	292	145	97	73
JUL	251	126	84	63	JUL	301	151	101	76
AUG	218	109	73	54	AUG	262	131	88	65
SEP	180	90	60	45	SEP	216	108	72	54
OCT	121	61	40	30	OCT	145	73	48	36
NOV	69	35	23	17	NOV	83	42	28	20
DEC	43	22	14	11	DEC	52	26	17	13

CENTRAL CALIFORNIA COAST

Warm-Season Turfgrasses

Minutes to irrigate/week if hourly sprinkler output is:

	0.5 in	1.0 in	1.5 in	2.0 in
JAN	38	19	13	09
FEB	50	25	17	13
MAR	63	32	21	16
APR	88	44	29	22
MAY	101	50	34	25
JUN	113	57	38	28
JUL	95	47	32	24
AUG	113	57	38	28
SEP	95	47	32	24
OCT	69	35	23	17
NOV	50	25	17	13
DEC	38	19	13	09

Cool-Season Turfgrasses

Minutes to irrigate/week if hourly sprinkler output is:

	0.5 in	1.0 in	1.5 in	2.0 in
JAN	50	25	17	13
FEB	67	34	22	17
MAR	84	42	28	21
APR	118	59	39	29
MAY	134	67	45	34
JUN	151	76	50	38
JUL	126	63	42	32
AUG	151	76	50	38
SEP	126	63	42	32
OCT	92	46	31	23
NOV	67	34	22	17
DEC	50	25	17	13

CENTRAL CALIFORNIA INLAND VALLEYS

Warm-Season Turfgrasses

Minutes to irrigate/week if hourly sprinkler output is:

	0.5 in	1.0 in	1.5 in	2.0 in
JAN	32	16	11	08
FEB	44	22	15	11
MAR	69	35	23	17
APR	95	47	32	24
MAY	113	57	38	28
JUN	113	57	38	28
JUL	132	66	44	33
AUG	126	63	42	32
SEP	107	54	36	27
OCT	76	38	25	19
NOV	44	22	15	11
DEC	32	16	11	08

Cool-Season Turfgrasses

Minutes to irrigate/week if hourly sprinkler output is:

	0.5 in	1.0 in	1.5 in	2.0 in
JAN	42	21	14	11
FEB	59	29	20	15
MAR	92	46	30	23
APR	126	63	42	32
MAY	151	76	50	38
JUN	151	76	50	38
JUL	176	88	59	44
AUG	168	84	56	42
SEP	143	71	48	36
OCT	101	50	34	25
NOV	59	29	20	15
DEC	42	21	14	11

SIERRA (TAHOE BASIN)

Warm-Season Turfgrasses

NOT RECOMMENDED

Cool-Season Turfgrasses

Minutes to irrigate/week if hourly sprinkler output is:

	0.5 in	1.0 in	1.5 in	2.0 in
JAN	31	15	10	08
FEB	43	22	14	11
MAR	79	39	26	20
APR	124	62	41	31
MAY	164	82	55	41
JUN	207	103	69	52
JUL	231	115	77	58
AUG	198	99	66	50
SEP	141	70	47	35
OCT	96	48	32	24
NOV	40	20	13	10
DEC	20	10	07	05

Nitrogen fertilizer sources generally are classified into two main categories: quickly available (fast-release) and slowly available (slow-release). This distinction refers to how fast the applied nutrients are available to the plant, and the length of time they remain available. Both quickly and slowly available sources of nitrogen fertilizer may be applied separately, (although they are commonly blended), along with P and K fertilizer sources, in a pre-packaged combination. Because of this packaging, fertilizers vary in the amount of quickly available and slowly available N, P, K, and other nutrients. This information is available on the product label.

Sources of nitrogen that are quickly available include inorganic salts such as ammonium sulfate, ammonium nitrate, and potassium nitrate, and organic forms such as urea and methylal urea. They are highly water-soluble. In California, ammonium sulfate is often the preferred quick-release fertilizer for general-use turfgrass due to its acidifying effect on high pH soils.

Many sports field and parks maintenance personnel in California routinely apply fast-release nitrogen products due to their low cost and convenience. It is important to remember that while fast-release fertilizers result in a more immediate turfgrass response than slow-release forms of nitrogen, greater skill is needed in their application to insure that the correct amount of nitrogen is applied and to avoid uneven spread. It is important to apply no more than one pound of quickly available nitrogen per 1,000 square feet in a single application.

Slowly available nitrogen products cost more than quickly available products, but do not require as frequent applications to provide an even supply of nitrogen. Longer-chained urea formaldehyde products such as Nitroform and Hydroform, and natural organic products such as bone meal and activated sewage sludge are dependent on higher temperatures and bacterial activity for release, while polymer-coated sulfur-coated urea (SCu) and isobutylidene diurea (IBDU) are less temperature dependent. Coated urea products slowly discharge urea through cracks in the coating. The urea enters the soil solution over a two or three month period. In many cases, slow-release nitrogen products result in less nitrogen loss due to leaching and volatilization than do quick-release fertilizers.

Although slow-release nitrogen products cost more than quick-release forms, they have a lower burn potential and are recommended for sandy soils and for use by entry-level employees who lack experience with fertilizer applications. They are also easier to use when grasscycling, since flushes of rapid growth are easier to avoid.

Besides nitrogen, phosphorus and potassium are nutrients that are also regularly applied to turfgrass. One or two annual applications of a complete fertilizer with a 3-1-2 or 4-1-2 ratio of N, P, and K are usually adequate to supply the phosphorus and potassium requirement of most bermudagrass sports fields. Phosphorus is necessary for nearly all metabolic processes involved in plant growth and development, and also regulates the formation and translocation of sugars and starches in the plant. Phosphorus deficiency symptoms include slow growth, stunting, and occasionally purplish leaves.

Potassium is important in water uptake and transport throughout the plant and for increased drought resistance. It also encourages root growth and is essential for cell growth and photosynthesis. Ammonia contained in some nitrogen fertilizers may reduce the amount of available potassium in the soil. Potassium sulfate provides sulfur in addition to potassium, and is often recommended in high pH soils to reduce alkalinity. Potassium deficiency symptoms include tip and margin burn on older leaves and slow growth.

Pruning and Training Landscape Trees

PRUNING IMMATURE LANDSCAPE TREES – Training and pruning immature trees is essential for insuring the development of mature trees with strong structures and desirable forms. Improperly pruned young, developing trees often require extensive corrective pruning in the future that could have been avoided.

The International Society of Arboriculture and other tree care organizations have developed pruning standards that will help insure the development of healthy, safe trees that provide maximum environmental benefit. Use of these standards are also an important factor in reducing unnecessary greenwaste production.

The International Society of Arboriculture offers the following insights into properly pruning young, maturing trees:

- Each cut has the potential to change the growth of the tree.
- There should be a purpose for each cut.
- Proper technique is essential. Poor pruning can cause damage that extends over the life of the tree. It is important to know where and how to make cuts before beginning the project.
- Trees do not "heal" the way people do. When a tree is wounded it must grow over and compartmentalize the wound. In effect, the wound is contained within the tree forever. Therefore, a small cut does less damage to the tree than a large cut. Waiting to prune a tree until it is mature can create the need for large cuts that cannot be easily compartmentalized.

Table 3. Inches and Gallons of Available Water for Four Different Soil Textures

Soil Type	Inches of available water per foot of soil depth	Gallons of available water per cubic foot of soil
Sand	0.5-1.0	0.33-0.67
Sandy loam	1.0-1.5	0.67-1.00
Clay loam	1.5-2.0	1.00-1.33
Clay	1.5-2.5	1.00-1.67

tions is often useful. To develop a budget, determine the water-holding capacity of the soil, and the desired depth of each irrigation (in general, trees should be watered about 2 feet deep). **Table 3** compares available water for four soil textures.

To determine the total water budget per tree, multiply the average water-holding capacity of the soil by 2 feet. For example, a sandy loam soil holding 1 inch of available water, multiplied by 2 feet equals 2 inches of water at field capacity. Since, in general, it is recommended that landscape trees be irrigated at 50 percent soil-moisture depletion, the tree should be irrigated when one inch of water has been depleted, and one inch should be added. Daily ETo measurements may be obtained through the CIMIS network, or historical averages may be utilized.

The following are additional methods of conserving water and reducing unnecessary organic matter production at landscape tree sites:

- Irrigate early in the morning to reduce soil evaporation.
- Irrigate trees separately from surrounding plants whenever possible.
- Avoid adding soil amendments to planting holes; they can lead to layered soil and prevent downward water movement resulting in shallow roots.
- Irrigate most frequently in spring and summer. When water is scarce, one or two thorough spring irrigations may supply enough water for the entire season.
- Keep turfgrass and other plants at least 1 foot from tree trunks.
- Apply mulch around trees, keeping it several inches from tree trunks. Mulch reduces water evaporation from the soil, buffers soil temperature, and reduces weeds. Irrigate thoroughly through the mulch layer into soil!
- Control weeds around trees. They compete for water and nutrients and can harbor insects and diseases.
- Avoid soil compaction around trees. Compaction restricts water movement into soil and decreases oxygen. Keep construction activities several feet from tree trunks.
- Do not routinely fertilize maturing trees. Nitrogen causes new growth flushes, increasing organic matter production and water requirements.
- Prune trees according to professional guidelines. Excess pruning and/or improper pruning promotes shoot growth that increases water demand.

Fertilizing Turfgrass

An understanding of nutrient needs of turfgrass is important for maintaining high quality plantings, and for making prudent, environmentally sound management decisions. Applying too much fertilizer can lead to undesirable rapid growth, resulting in large amounts of turfgrass clippings that are difficult to grasscycle.

There are 16 essential nutrients required by turfgrass, classified as either macro- or micronutrients. While micronutrients are just as important for plant growth and development as macronutrients, they are required in lower concentrations. Essential macronutrients not supplied by air and water but required for plant growth and development (and their corresponding chemical symbols) are: Nitrogen (N); Phosphorus (P); Potassium (K); Calcium (Ca); Magnesium (Mg); and Sulfur (S).

Essential micronutrients and their corresponding chemical symbols are: Iron (Fe); Manganese (Mn); Zinc (Zn); Copper (Cu); Molybdenum (Mo); Boron (B); and Chlorine (Cl).

By far, nitrogen is the most limiting nutrient and is required in the greatest amount by turfgrass. Nitrogen-deficient turfgrasses will grow slowly, appear chlorotic and thin, and not withstand traffic well.

One or two applications of a complete fertilizer that contains nitrogen, phosphorus, and potassium is recommended to fertilize most turfgrasses annually. A ratio of 3-1-2 or 4-1-2 of nitrogen, phosphorus and potassium, respectively, as found in formulations like 12-4-8 or 20-5-10, best matches the relative nutrient needs of these grasses. Four to five additional pounds of actual nitrogen per 1,000 square feet are required throughout the growing season to maintain high quality playing fields and golf courses, but are not necessary for lawns and less-intensively used sites.

corresponding grid that indicates the field location of each can for future reference. Determine the average depth of water in each can and multiply this number by four to determine the sprinkler output in inches per hour (precipitation rate).

If possible, conduct the can test at the same time of day the turfgrass is ordinarily watered since water pressure often varies over a 24-hour period. Also, avoid conducting the test during an unusually windy period.

2 Determine the length of time to irrigate the turfgrass

Use the appropriate geographical area in **Table 1** that most closely matches the location of the turfgrass planting to be irrigated. Use the precipitation rate in the corresponding table that comes closest to, but does not exceed, the output rate determined in **1**. The columns of numbers in **Table 1** indicate the total number of minutes to irrigate over a one week period. Divide the total minutes into two, three or four irrigations per week, depending on how many minutes a single irrigation can run before runoff starts.

On slopes and soils that do not absorb water quickly, irrigation cycling is recommended. This entails irrigating to the point that runoff starts, waiting ten or fifteen minutes, and irrigating a second time, and, sometimes, a third time, until the required amount of water for that particular day has been applied. Turfgrass benefits from drying down somewhat between irrigations, to encourage deep rooting. In general, turfgrass should not be irrigated more often than four times a week, with the exception of some golf course putting greens. Controllers should be reset at least monthly during the summer and at least quarterly during the rest of the year to match seasonal changes in irrigation requirements, based on **Table 1**.

METHOD2

This method of irrigation scheduling relies on results of a more precise can test than **Method 1**; offers the option of using real-time ETo information available through the California Irrigation Management Information System (CIMIS); discusses the use of tensiometers; and describes how to mathematically determine distribution uniformity (DU), application rate, net amount of water to apply, and sprinkler run times.

1 Use either real-time or historical records to estimate reference evapotranspiration (ETo).

ETo is an estimate of the amount of water used by healthy 4- to 6-inch-tall cool-season turfgrass. Real-time ETo is based on measurements of current environmental conditions that determine plant water use, as opposed to average conditions for a certain time of year, used in **Method 1**. These measurements include solar radiation, air temperature, wind speed, and relative humidity.

The California Irrigation Management Information System (CIMIS), managed by the California Department of Water Resources, provides real-time ETo data at several locations in California. Turfgrass plantings in areas of close proximity to these locations have similar ETo requirements. Real-time ETo from CIMIS can be downloaded on microcomputers. For more information on CIMIS, contact the California Department of Water Resources at 1-800-92 CIMIS.

Historical ETo records are compiled from several years of meteorological data measured at many locations in California during an average year and can be a very accurate estimate of ETo.

Table 2 indicates monthly ETo rates throughout California.

Table 2. Average Monthly Reference Evapotranspiration (ETo) Rates in California (in inches)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NE Mountain Valleys	0.62	1.16	2.17	3.60	4.96	5.70	8.06	7.13	4.80	2.79	0.90	0.62
Northern Coast	0.62	1.16	1.86	2.40	3.41	3.60	3.41	3.41	2.70	1.86	1.20	0.62
Northern Inland Valleys	0.93	1.16	2.48	3.30	4.96	6.00	7.13	6.20	4.50	2.79	1.20	0.62
Sacramento Valley	1.24	1.74	3.10	4.50	5.89	7.20	8.06	6.82	5.10	3.41	1.80	0.93
San Joaquin Valley	0.93	1.74	3.10	4.50	6.51	7.50	7.75	6.51	4.80	3.41	1.50	0.62
Central Coast	1.86	2.32	3.10	3.90	4.65	4.80	5.27	4.96	3.90	3.10	2.10	1.55
Central Inland Valleys	1.55	2.32	3.41	4.20	5.58	6.30	6.82	5.89	4.80	3.72	2.40	1.55
Sierra (Tahoe Basin)	-----	-----	-----	3.00	4.03	4.80	6.20	5.27	3.00	2.79	-----	-----
Southern Coast	1.86	2.61	3.10	3.90	4.34	5.10	5.58	5.58	4.50	3.41	2.70	2.10
Southern Inland Valleys	1.86	2.61	3.41	4.20	4.96	6.00	6.82	6.82	5.10	3.72	2.40	1.80
Southern CA Deserts	2.79	3.77	5.89	7.50	10.23	11.40	11.47	9.61	8.40	6.20	3.60	1.86

2 Assign an appropriate percentage of ETo to the turfgrass to be irrigated.

Warm-season turfgrasses (bermudagrass, zoysiagrass, St. Augustinegrass) require about 20 percent less water than cool-season turfgrasses (tall fescue, annual and perennial ryegrass, bluegrass), and should be irrigated at 60 percent of ETo, while cool season turfgrasses require at least 80 percent of ETo to maintain optimum quality.

Example. In July, a bermudagrass park located in San Bernardino has the following water requirements for optimal growth in an average year:

6.82 inches x .6 = 4.1 inches

Table 2 indicates that historical ETo in July in Southern Inland Valleys totals 6.82 inches. Multiplying 6.82 times the suggested percent reference ETo for warm season turfgrass (.6) indicates the water requirement for July to be 4.1 inches.

3 Determine an acceptable allowable soil-moisture depletion rate.

Knowing when to irrigate is as important as knowing how much irrigation water to apply. While it is important to let turfgrass dry down some between irrigations, it is also important to apply water before significant symptoms of drought stress occur.

Tensiometers and other soil moisture measuring devices can be very helpful in determining maximum allowable soil-moisture depletion. During the summer, a tensiometer reading of 60 centibars at a 6-inch to 1-foot soil depth approaches the maximum allowable soil-moisture depletion for warm-season turfgrass. A reading of 40 centibars at a 4-inch depth identifies the maximum allowable depletion for cool-season grass. (Remember that the higher the centibar reading, the drier the soil.)

4 Determine the distribution uniformity (DU) of the irrigation system

The easiest and most accurate method to determine the distribution uniformity (DU) of a sprinkler system is to conduct a can test. A major goal of irrigating turfgrass is to obtain the highest DU possible to provide optimum conditions for turfgrass growth throughout the planted area and to reduce water waste. Straight-sided cans are useful for conducting can tests since water collected during the sample run can easily be measured with a ruler. Alternatively, cans without straight sides may be used, although volumetric measurements are then required.

After laying out the cans to perform the can test in either 10-foot or 15-foot centers, operate the sprinkler system for 15 minutes. Then, measure and record the amount of water in each can on a site map. Determine the average (mean) amount of water per can. Next, calculate the average amount of water that accumulated in the "low quarter." For example, if there were 100 total cans in the test, the overall mean average of water in all the cans should be determined first. Then, the average amount of water in the 25 cans that accumulated the least amount of water (the low quarter) is calculated and recorded. The DU can then be determined using the following formula:

$$\text{Distribution Uniformity (DU)} = \frac{\text{Mean of the Low Quarter}}{\text{Overall Mean}} \times 100$$

5 Determine the net amount of irrigation water to apply.

Divide the monthly percent ETo used in **2** by the DU calculated in **4**.

6 Determine the hourly sprinkler system application rate.

Multiply the average amount of water per can from the can test (**4**) by four, since the test was conducted for 15 minutes.

7 Determine the sprinkler run time.

The sprinkler run time is the net amount of water to apply (determined in **5**) divided by the sprinkler system application rate (determined in **6**). This number multiplied by 60 equals the run time in minutes.

Example: If 0.50 inches of water needs to be applied during each irrigation and the application rate is 1.0 inch/hour, the run time equals 0.50 hours or 30 minutes:

0.50/1.0 = 0.50 hours, and 0.50 x 60 = 30 minutes

Other considerations in turfgrass irrigation management

It is very important to maintain a high DU to maintain healthy turfgrass plantings and avoid unnecessary water waste. **Table 1** assumes an 80 percent DU. A system with a DU of 40 percent requires twice as much water as a system with a DU of 80 percent! Even with limited resources, conducting regular can tests is a sound investment, and often leads to substantial savings of water and money, unnecessary greenwaste production, and a healthier turfgrass planting less prone to pests.

Runoff is an excellent indicator of how long an irrigation cycle may run. Simply measure the length of time it takes for runoff to begin from the time the system turns on. This is the maximum length of time the system should be run during each irrigation. If necessary, irrigations may be cycled by adding smaller amounts of water during each irrigation to allow the water to soak into the soil before adding more water, and repeat the cycle. It is important that the cycles are repeated over a short period of time, before the soil dries significantly. Several cycles may be required.

Scheduling irrigations around sports field and golf course usage—without sacrificing turfgrass quality or field safety—is an important consideration for many turfgrass professionals. Early morning irrigation is preferred. Irrigation should occur long enough before play to avoid wet conditions during games, since wet soils compact easily, leading to stressed grass and poor playing conditions.

Scheduling regular walk-throughs to identify and correct problems with irrigation equipment on site is as important to the overall health and function of the turfgrass planting as is irrigation scheduling. When an irrigation system is inoperative for even a day or two under high summer temperatures, drought stress can lead to temporary damage to the turfgrass. In many cases, substantial amounts of water loss due to a low DU can be avoided by checking equipment regularly.

One of the most important steps to take to avoid low DU's leading to brown spots and wasted water is to maintain a well-stocked inventory of matched irrigation components for emergencies. Additionally, parts such as piping, repair couplings, isolation valves, electric valves, quick coupling valves, swing joints, fittings, concrete for thrust blocks, wire, wire connectors, and a volt meter should be readily available. It is wise to have at least one person knowledgeable in irrigation equipment and scheduling who can monitor irrigation functions regularly throughout the site.

Sprinklers should be regularly checked for the following common causes of poor distribution uniformity and necessary repairs made as soon as possible: broken sprinklers; unmatched sprinklers; sunken sprinklers; crooked sprinklers; turfgrass growing around sprinklers; and sand or debris plugging sprinklers.

Landscape Tree Irrigation

Most landscape trees require at least some water throughout their establishment period. Properly scheduling irrigations based on reference evapotranspiration (ETo) and applying the water into the root zone play important roles in the structural integrity and health of the tree, water conservation, and limiting excess organic matter production. It is important to routinely check and correct sprinkler problems such as misdirected heads—that apply large volumes of water to sidewalks and parking lots—and clogged nozzles on drip irrigation systems.

IRRIGATION SCHEDULING–Because landscape trees are planted in varying densities and are often mixed with shrubs, groundcovers, and turfgrasses, the use of crop coefficients cannot be legitimately used to schedule irrigations. However, studies indicate that maturing trees receiving 40 to 60 percent of reference evapotranspiration (ETo) often perform as well as trees receiving 80 to 100 percent ETo, with the added benefit of reduced foliar growth and organic matter production. **Table 2** indicates monthly ETo rates throughout California.

Landscape trees prefer more infrequent, deep irrigations than do non-woody plants such as turfgrass. Knowing when to irrigate is as important as knowing how much water to apply. Soil texture and species preference largely determine when to irrigate. Using a water budget approach in scheduling landscape irriga-

Table 2. Average Monthly Reference Evapotranspiration (ETo) Rates in California (in inches)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NE Mountain Valleys	0.62	1.16	2.17	3.60	4.96	5.70	8.06	7.13	4.80	2.79	0.90	0.62
Northern Coast	0.62	1.16	1.86	2.40	3.41	3.60	3.41	3.41	2.70	1.86	1.20	0.62
Northern Inland Valleys	0.93	1.16	2.48	3.30	4.96	6.00	7.13	6.20	4.50	2.79	1.20	0.62
Sacramento Valley	1.24	1.74	3.10	4.50	5.89	7.20	8.06	6.82	5.10	3.41	1.80	0.93
San Joaquin Valley	0.93	1.74	3.10	4.50	6.51	7.50	7.75	6.51	4.80	3.41	1.50	0.62
Central Coast	1.86	2.32	3.10	3.90	4.65	4.80	5.27	4.96	3.90	3.10	2.10	1.55
Central Inland Valleys	1.55	2.32	3.41	4.20	5.58	6.30	6.82	5.89	4.80	3.72	2.40	1.55
Sierra (Tahoe Basin)	-----	-----	-----	3.00	4.03	4.80	6.20	5.27	3.00	2.79	-----	-----
Southern Coast	1.86	2.61	3.10	3.90	4.34	5.10	5.58	5.58	4.50	3.41	2.70	2.10
Southern Inland Valleys	1.86	2.61	3.41	4.20	4.96	6.00	6.82	6.82	5.10	3.72	2.40	1.80
Southern CA Deserts	2.79	3.77	5.89	7.50	10.23	11.40	11.47	9.61	8.40	6.20	3.60	1.86

NORTHEASTERN MOUNTAIN VALLEYS

Warm-Season Turfgrasses	Cool-Season Turfgrasses				
		Minutes to irrigate/week if hourly sprinkler output is:			
		0.5 in	1.0 in	1.5 in	2.0 in
	JAN	17	08	06	04
	FEB	34	17	11	08
	MAR	59	29	20	15
	APR	101	50	34	25
	MAY	134	67	45	34
NOT RECOMMEDED	JUN	168	84	56	42
	JUL	210	105	70	53
	AUG	176	88	59	44
	SEP	126	63	42	32
	OCT	76	38	25	19
	NOV	25	13	09	06
	DEC	17	09	06	04

NORTH COAST

Warm-Season Turfgrasses	Cool-Season Turfgrasses				
		Minutes to irrigate/week if hourly sprinkler output is:			
		0.5 in	1.0 in	1.5 in	2.0 in
	JAN	15	07	05	04
	FEB	36	18	12	09
	MAR	55	27	18	14
	APR	6	34	22	17
	MAY	88	44	29	22
NOT RECOMMENDED	JUN	97	48	32	24
	JUL	95	47	32	24
	AUG	90	45	30	23
	SEP	76	38	25	19
	OCT	48	24	16	12
	NOV	32	16	11	08
	DEC	21	11	07	05

NORTH INLAND VALLEYS

	Warm-Season Turfgrasses					Cool-Season Turfgrasses			
	Minutes to irrigate/week if hourly sprinkler output is:					Minutes to irrigate/week if hourly sprinkler output is:			
	0.5 in	1.0 in	1.5 in	2.0 in		0..5 in	1.0 in	1.5 in	2.0 in
JAN	19	09	06	05	JAN	25	13	08	06
FEB	32	16	11	08	FEB	42	21	14	11
MAR	50	25	17	13	MAR	67	34	22	17
APR	69	35	23	17	APR	92	46	31	23
MAY	101	50	34	25	MAY	134	67	45	34
JUN	126	63	42	32	JUN	168	84	56	42
JUL	132	66	44	33	JUL	176	88	59	44
AUG	120	60	40	30	AUG	160	80	53	40
SEP	95	47	32	24	SEP	126	63	42	32
OCT	57	28	19	14	OCT	76	38	25	19
NOV	25	13	08	06	NOV	34	17	11	08
DEC	13	06	04	03	DEC	17	08	06	04

SACRAMENTO VALLEY

Warm-Season Turfgrasses

Minutes to irrigate/week if hourly sprinkler output is:

	0.5 in	1.0 in	1.5 in	2.0 in
JAN	19	09	06	05
FEB	44	22	15	11
MAR	69	35	23	17
APR	101	50	34	25
MAY	126	63	42	32
JUN	158	79	53	39
JUL	164	82	55	41
AUG	145	72	48	36
SEP	113	57	38	28
OCT	82	41	27	20
NOV	38	19	13	09
DEC	19	09	06	05

Cool-Season Turfgrasses

Minutes to irrigate/week if hourly sprinkler output is:

	0..5 in	1.0 in	1.5 in	2.0 in
JAN	25	13	08	06
FEB	59	29	20	15
MAR	92	46	31	23
APR	134	67	45	34
MAY	168	84	56	42
JUN	210	105	70	53
JUL	218	109	73	55
AUG	193	97	64	48
SEP	151	76	50	38
OCT	109	55	36	27
NOV	50	25	17	13
DEC	25	13	08	06

SAN JOAQUIN VALLEY

Warm-Season Turfgrasses

Minutes to irrigate/week if hourly sprinkler output is:

	0.5 in	1.0 in	1.5 in	2.0 in
JAN	19	09	06	05
FEB	38	19	13	09
MAR	69	35	23	17
APR	101	50	34	25
MAY	132	66	44	33
JUN	164	82	55	41
JUL	170	85	57	43
AUG	145	72	48	36
SEP	113	57	38	28
OCT	69	35	23	17
NOV	32	16	11	08
DEC	13	06	04	03

Cool-Season Turfgrasses

Minutes to irrigate/week if hourly sprinkler output is:

	0..5 in	1.0 in	1.5 in	2.0 in
JAN	25	13	08	06
FEB	50	25	17	13
MAR	92	46	31	23
APR	134	67	45	34
MAY	176	88	59	44
JUN	218	109	73	55
JUL	227	113	76	57
AUG	193	97	64	48
SEP	151	76	50	38
OCT	92	46	31	23
NOV	42	21	14	11
DEC	17	08	06	04

CIWMB Publication #443-01-022 Revised June 2001

For additional copies of this publication, contact: California Integrated Waste Management Board, Public Affairs Office-Publications Clearinghouse (MS-6), P.O. Box 4025, Sacramento, CA 95812-4025. Order online at www.ciwmb.ca.gov/Publications/ or call 1-800-CA-WASTE (California only) or (916) 341-6306.

The energy challenge facing California is real. Every Californian needs to take immediate action to reduce energy consumption. For a list of simple ways you can reduce demand and your energy costs, see the CIWMB Web site at www.ciwmb.ca.gov.

References

Beard, J.B. 1973. Turfgrass Science and Culture. Prentice, Hall, Englewood Cliffs, N.J.

California Environmental Protection Agency, Integrated Waste Management Board. 1996. Grasscycling: Send Your Grass Back to its Roots: Publication #500-94-007.

Harivandi, A. and V.A. Gibeault. 1999. Mowing Your Lawn and Grasscycling. UC DANR Leaflet 2587.

Harris, R. A., J..R. Clark, and N .P. Matheny. Arboriculture: Integrated Management of Landscape Trees, Shrubs, and Vines. 3rd edition. 1998. Prentice-Hall, Englewood Cliffs, N.J.

Hartin, J.S., V.A. Gibeault and J.L. Meyer. 1995. Scheduling Turfgrass Irrigations. Turf Tales Magazine.

International Society of Arboriculture. 1997. Tree Care Consumer Information: Mature Tree Care. Champaign, IL.

International Society of Arboriculture. 1997. Tree Care Consumer Information: New Tree Planting. Champaign, IL .

International Society of Arboriculture. 1997. Tree Care Consumer Information: Plant Health Care. Champaign, IL.

International Society of Arboriculture. 1997. Tree Care Consumer Information: Why Topping Hurts Trees. Champaign, IL.

Larson, T. 1995. Greenwaste Recycling: Closing the Loop. California Landscaping, March Issue.

Shigo, A.L. 1993. 100 Tree Myths. Shigo and Tree Associates, Durham, NH.

Shigo, A.L. 1991. Modern Arboriculture: A Systems Approach to the Care of Trees and Their Associates. Shigo and Tree Associates, Durham, NH.

Western Fertilizer Handbook – Horticulture Edition. 1990. California Fertilizer Association, Interstate Publishers, Dasnville, Ill.

Additional Resources

The California Integrated Waste Management Board's "Commercial Landscaping" Web site (www.ciwmb.ca.gov/Organics/Landscaping/) contains helpful information and a listing of publications for online ordering or downloading on using landscape management practices that reduce waste generation, reuse trimmings on site, and recycle organic products (mulch and compost) back into urban landscapes while also saving time and money.

Printed on recycled paper